Bank leverage shocks and the macroeconomy: a new look in a data-rich environment

Jean-Stéphane Mesonnier[1] and Dalibor Stevanovic[2]

[1]Banque de France

[2]EUI and UQAM

October 2012

Motivation

- Overstretched leverage of large US financial institutions a major culprit of accumulation of risks leading to the subprime crisis
- As result, Basel 3 package includes a substantial increase in quantity and quality of core capital relative to risk-weighted assets: potential large shock on bank leverage
- Empirical question: **what are the macroeconomic consequences of shocks reducing bank leverage?**
  - Vivid debate: IIF (2010) vs Admati et al. (2010)
  - Macroeconomic Assessment Group (Basel): negative effects in the short-run (transition) but positive in the long-run?
  - Severe methodological shortcomings in the attempt to reconcile facts observed at the micro level and assessment of macro effects.

In this paper...

- A new approach to assess the macroeconomic consequences of a shock to the capital-to-asset ratio (CAR) of large US bank holding companies (BHC)
- ... relying on a rich database of both bank balance sheet informations (micro-level) and macroeconomic aggregates:
  - Construct measures of exogenous CAR shocks at bank level, using a dynamic model of bank capital ratios
  - Estimate the dynamic responses of a large set of macroeconomic variables to the previously aggregated bank leverage shock using the new FADL methodology from Ng and Stevanovic (2011).
- Aims to benefit from combined advantages of existing approaches, while overcoming limitations:
  - bank-level panel regressions: potentially good identification of capital shock
  - monetary VARs with bank leverage: potentially useful to catch general equilibrium effects

Main results

- Leverage shocks matter for understanding credit aggregates variations as well as the US business cycle.
- A 10 basis points unexpected rise in CAR causes:
  - Significant and persistent fall in the growth of loans
  - Total commercial bank credit contracts by some 1% on impact and 3% over 6 quarters, but rates on C&I loans shoot up
  - Short-run fall of investment, consumption and GDP
  - Asymmetric effects of leverage reducing and leverage increasing shocks; the former matter much more.
- Compare our results with IRFs obtained with alternative measure of leverage shock from a small-scale macro VAR (Berrospide and Edge, 2010)
  - highlights benefits from use of micro data for identification

Related literature

- Identification of credit supply effects in macro VARs using relevant "non-credit" banking indicators: share of assets in impaired banks (Peek, Rosengren and Tootel, 1999, 2003), lending standards (Lown and Morgan, 2006, Ciccarelli et al., 2011, Basset et al., 2011)
- Papers using bank-level regressions to gauge the effects of bank capital (more precisely bank leverage) on lending (Hancock and Wilcox, 1994, Kashyap and Stein, 2000 or Berrospide and Edge, 2010)
- FAVAR models combining micro (bank-level) and macro datasets (Buch, Eckmeier et al., 2010, Dave, Dressler, Zhang, 2009, Jimborean and Mesonnier, 2010,)

Overview of modeling strategy: four steps

1. Extraction of "structural" macroeconomic "non-bank related" shocks from a large macro dataset X using a dynamic factor model: vector of "non-bank" macro shocks $\widehat{\eta}_t$

Overview of modeling strategy: four steps

1. Extraction of "structural" macroeconomic "non-bank related" shocks from a large macro dataset X using a dynamic factor model: vector of "non-bank" macro shocks $\widehat{\eta}_t$
2. Estimation of bank-level shocks to the CAR, $\widehat{\varepsilon}_{i,t}$, using a standard dynamic model of bank capital $k_{i,t}$ that includes the macro shocks $\widehat{\eta}_t$ as regressors

Overview of modeling strategy: four steps

1. Extraction of "structural" macroeconomic "non-bank related" shocks from a large macro dataset X using a dynamic factor model: vector of "non-bank" macro shocks $\widehat{\eta}_t$
2. Estimation of bank-level shocks to the CAR, $\widehat{\varepsilon}_{i,t}$, using a standard dynamic model of bank capital $k_{i,t}$ that includes the macro shocks $\widehat{\eta}_t$ as regressors
3. Aggregation of the bank $\widehat{\varepsilon}_{i,t}$ into a macro measure of CAR shocks $\widehat{\varepsilon}_t$

Overview of modeling strategy: four steps

1. Extraction of "structural" macroeconomic "non-bank related" shocks from a large macro dataset X using a dynamic factor model: vector of "non-bank" macro shocks $\widehat{\eta}_t$
2. Estimation of bank-level shocks to the CAR, $\widehat{\varepsilon}_{i,t}$, using a standard dynamic model of bank capital $k_{i,t}$ that includes the macro shocks $\widehat{\eta}_t$ as regressors
3. Aggregation of the bank $\widehat{\varepsilon}_{i,t}$ into a macro measure of CAR shocks $\widehat{\varepsilon}_t$
4. Estimation of IRF of variables in main macro database X or ancillary credit-banking macro database Y using FADL methodology (Ng & Stevanovic, 2012).

Estimation of macroeconomic shocks 1

- Assume that X_t has a dynamic factor representation:

$$X_t = \lambda(L) f_t + u_t \quad (1)$$
$$u_t = D(L) u_{t-1} + v_{Xt} \quad (2)$$
$$f_t = \Gamma_1(L) f_{t-1} + \Gamma_0 v_{ft} \quad (3)$$

- f_t: q common factors that evolve as a vector autoregressive (VAR) process of order h,
- $\lambda(L)$ is a polynomial matrix of factor loadings of order s,
- $D(L)$ is a diagonal polynomial matrix,
- v_{Xt} is a vector white noise process, v_{ft} is a vector of q structural shocks such as demand, supply or monetary policy,
- characteristic roots of $\Gamma_1(L)$ are strictly less than one, $E(v_{Xit} v_{Xjt}) = 0$, and $E(v_{Xit} v_{fkt}) = 0$ for all $i \neq j$ and for all $k = 1, \ldots q$.

Estimation of macroeconomic shocks 2

- Static factor representation of $x_t = (I - D(L)L)X_t$:

$$x_t = \Lambda F_t + v_{Xt} \quad (4)$$
$$F_t = \Phi_F F_{t-1} + \epsilon_{Ft} \quad (5)$$

  - where $\epsilon_{Ft} = G\eta_t$, Λ be the $N \times r$ matrix of loadings, F_t is $r = q(s+1) \times 1$

- **Step 1:** Estimate F_t by IPC as in Stock and Watson (2005).
- **Step 2:** Estimate $\eta_t = v_{ft}$:
  1. Let $\hat{\epsilon}_{Xit} = x_{it} - \hat{\Lambda}_i' \hat{\Phi}_F \hat{F}_{t-1}$.
  2. The estimate of η_t consists of first q principal components of $\hat{\epsilon}_{Xit}$.

  - Use information criteria from Amengual and Watson (2007), and Bai and Ng (2007) to estimate q.

Macroeconomic data

- A rich macroeconomic dataset for two joint purposes:
  - to uncover real and nominal shocks spanning macro fluctuations, aside from bank leverage shocks.
  - to compute IRFs for a large set of macro variables.
- Two separate macroeconomic datasets:
  - A selection of 31 real, nominal and financial series representing the US economy, with the exclusion of any banking/credit/money indicator, stacked in X.
  - A complementary set of 14 macro credit and banking indicators, stacked in Y.

Macroeconomic data

- 31 real, nominal and financial series in X:
  - close to the selection in Gilchrist et al. (2009). Limited number of series in line with recommendation in Boivin and Ng (2006) and Onatski (2009), in order to avoid problem of weak factor structure.
  - 4 blocks: real economic activity (12 series), prices (7), term structure of interest rates (7), assets prices (NEER, S&P500, AAA & BAA spreads, FHFA housing price index).
- 14 credit and banking indicators in Y:
  - total US commercial bank credit and its components (H8 Release of the Fed)
  - interest rates on loans (personal, car, C&I) (SCC and STBL)
  - Credit standards (SLOOS)
  - Aggregate leverage of US commercial banks (as in Berrospide and Edge, 2010).

A standard dynamic model of bank leverage targeting

- Following on Hancock and Wilcox (1994) among others, we assume:

$$k_{i,t} - k_{i,t-1} = \lambda \left(k^*_{i,t-1} - k_{i,t-1} \right) + e_{i,t} \qquad (6)$$

where $k_{i,t}$: actual capital ratio at period t for institution i, $k^*_{i,t}$: target capital ratio, λ drives adjustment speed.

- Bankers assumed to set their target in light of individual info and macro outlook: $k^*_{i,t-1} = \theta_Z . Z_{i,t-1} + \theta_M . M_{i,t-1}$.
- Problem: bank-specific innovations to leverage $e_{i,t}$ may not be orthogonal to macro shocks occurring between $t-1$ and t, like exogenous credit demand or monetary policy shocks.

Extracting structural bank leverage shocks

- Suppose that observed macroeconomic fluctuations can be subsumed to the propagation of a small number of unobserved common shocks, $\eta_t = v_{ft}$ (cf. macro factor model above).
- Then, innovations $e_{i,t}$ may be partly driven by these shocks:

$$e_{i,t} = \theta_\eta.\eta_t + \varepsilon_{i,t}$$

- Replacing in equation (6), rearranging and adding bank FE, we finally get:

$$k_{i,t} = \alpha_i + (1-\lambda).k_{i,t-1} + \lambda.\theta_Z.Z_{i,t} + \lambda.\theta_M.M_t + \theta_\eta.\eta_t + \varepsilon_{i,t} \quad (7)$$

- Now, the $\varepsilon_{i,t}$ can be interpreted as structural shocks to individual banks' capital ratios Possible causes are manyfold (changes in regulatory environment, in bank specific requirements, in the business model or risk strategy of the bank, windfall P&L etc.)

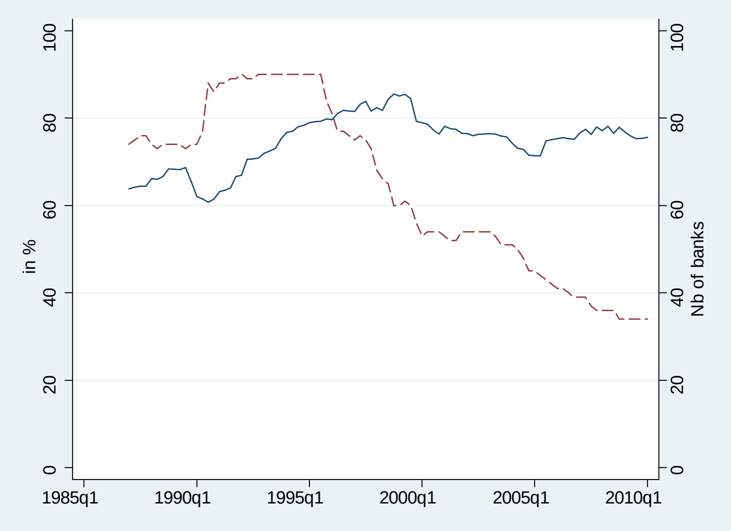
Estimation of bank capital model: regressors

- Usual bank-specific determinants of target capital ratio:
  - Size, ROA, net charge-offs, asset composition (mortgage and C&I loan shares).
- Measures of global risk and macroeconomic expectations:
  - Stock market volatility (VIXX), expected changes in short term rate and GDP growth from Phil Fed SPF.
- 3 unobserved macro shocks extracted from "non-banking" macro dataset X.
- Dummies for M&As, FHC status, seasonality.
- Bank FE.

Bank balance sheet data

- *Consolidated* balance sheet information for all US Bank holding corporations (BHC) from the Federal Reserve's "Call reports". Highly unbalanced panel (819 banks present, but only 66 throughout).
- Period of 1986 Q2 to 2010 Q1, potentially including large shocks to US banks' leverage.
- Focus on large BHCs (assets always above $ 3 bns).
- Trade-off stability vs selection bias: keep only banks present more than 8 consecutive years.
- We end up with an unbalanced panel of 104 banks (only 20 present over whole period), representing 75% of total banking assets on average.

Share of our sample of banks in total US BHC assets and number of banks in sample through time



Bank balance sheet data: institutional and statistical issues

- Consolidation wave of the US financial banking sector since the late 1980s: M&A identified using Fed of Chicago database (356 M&A in our sample).
- Impact of the Gramm-Leach-Bliley Financial Modernization Act of 1999: identification of switches from BHC to FHC status using reports from the US National Information Center of Financial institutions.
- Reporting break in 2006 Q1: large subsidiaries (assets above $ 1bn) do not have to fill separate reporting anymore.

Summary stats for bank variables

	N	mean	sd	p50
Assets ($ mns)	6,137	76,365.25	216220.96	19,709.15
Capital-to-assets	6,137	8.05	5.13	7.54
ROA	6,137	2.64	3.33	2.42
Loans-to-assets	6,137	60.52	14.99	64.10
Mortgage loans-to-assets	6,137	26.46	12.76	26.46
C&I loans-to-assets	6,137	16.26	8.01	15.87
Net chargeoffs-to-assets	6,137	1.16	1.46	0.70

Regression results

	MICRO		EXP-SWIPC	
Lagged Capital ratio	0.933***	(98.48)	0.931***	(94.72)
Size	0.094***	(3.73)	0.099***	(3.95)
ROA	-0.006	(-1.45)	-0.006	(-1.60)
Net chargeoff	0.026**	(2.31)	0.024**	(2.18)
Real estate loans	-0.002	(-1.07)	-0.002	(-1.29)
C&I loans	-0.005**	(-2.09)	-0.004	(-1.46)
FHC status	0.010	(0.21)	0.020	(0.39)
Mergers	0.105**	(2.52)	0.106**	(2.54)
SP500 volatility			-0.039**	(-2.14)
Exp. change policy rate			0.055**	(2.57)
Exp. change GDP growth			-0.033	(-1.64)
SWIPC1			0.023*	(1.86)
SWIPC2			0.009	(1.27)
SWIPC3			-0.002	(-0.26)
Observations	6026		6026	
R^2	0.873		0.873	

Robust t-stats betw. ().

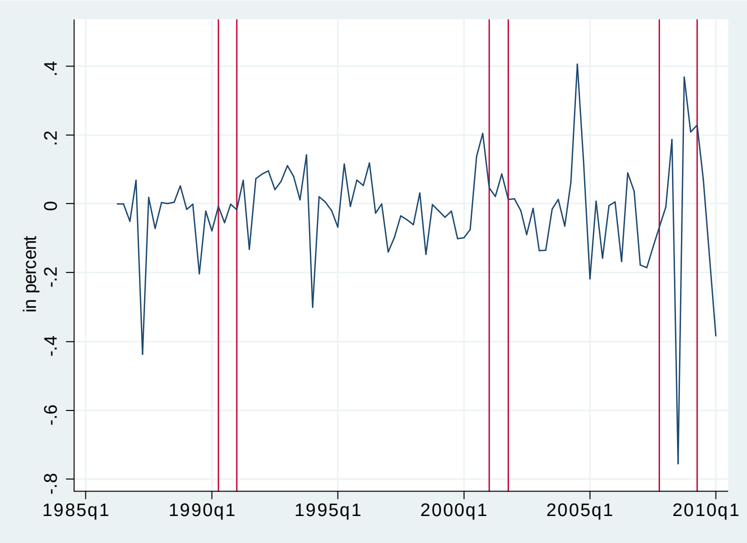
Aggregation

- We aggregate individual capital ratio shocks as a weighted average over the banks present at each period:

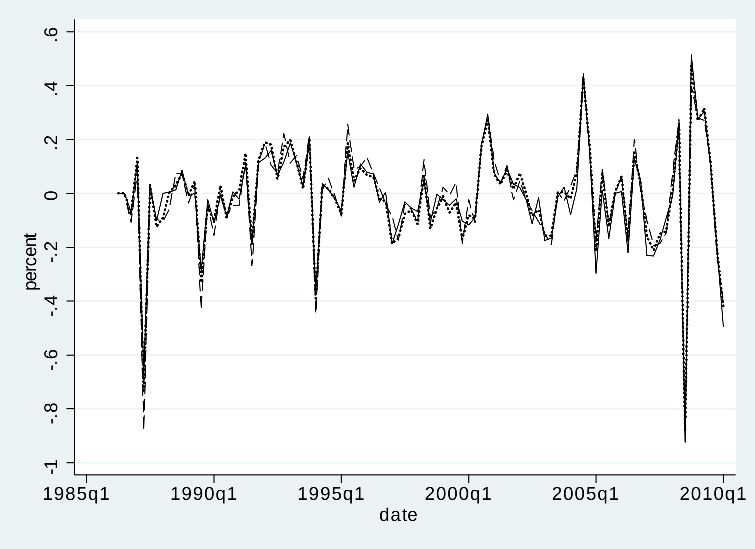
$$\widehat{\varepsilon}_t = \sum_{i=1}^{\widetilde{N}_t} a_{i,t-1}.\widehat{\varepsilon}_{i,t}$$

-
  - where $\widetilde{N}_t = \min(N_t, N_{t-1})$ and $a_{i,t-1}$ is the share of bank i in the sample at $t-1$.
  - See Figure 2 below.
- Estimate of $\widehat{\varepsilon}_t$ robust to smaller sample of banks (25-50 biggest)
- How to interpret a positive shock ε_t?
  - "Good" vs "bad" deleveraging, depending on the signs of ΔK and ΔA
  - Hints from correlations at bank level, see Table 4

Estimated aggregate bank capital ratio shocks



Estimated aggregate bank capital ratio shocks, different sample of banks (all 104 vs 25-50 largest)



Capital ratio shocks and bank assets growth at bank level

			$\Delta(\text{Assets}_{i,t})$	
			< 0	> 0
$\varepsilon_{i,t} < 0$	$\Delta(\text{Equity}_{i,t})$	< 0	5.4	11.4
		≥ 0	1.8	31.9
$\varepsilon_{i,t} \geq 0$	$\Delta(\text{Equity}_{i,t})$	< 0	3.1	0.3
		≥ 0	21.1	25.2

Table: Breakdown of individual capital ratio shocks according to the sign of contemporaneous changes in bank equity and total assets (in percent of total number of individual shocks).

FADL model and Impulse response analysis

- Main idea of FADL methodology is to augment an autoregression of a variable of interest, y_t, with current and lagged values of $\hat{\eta}_t$ and $\hat{\varepsilon}_t$:

$$y_t = \alpha_y(L)y_{t-1} + \alpha_\eta(L)\hat{\eta}_t + \alpha_\varepsilon(L)\hat{\varepsilon}_t + v_{yt}. \qquad (8)$$

- If $y_t \in X_t$, its FADL representation is derived from dynamic factor model.
- If the leverage shock is important for (idiosyncratic part of) y_t, the corresponding coefficients should be significant.
- To construct the impulse responses, estimate (8) by OLS. The impulse response function of y_t to a unit increase in $\hat{\varepsilon}_t$ is defined by

$$\hat{\psi}_y^\varepsilon(L) = \frac{\hat{\alpha}_\varepsilon(L)}{1 - \hat{\alpha}_y(L)L}.$$

Advantages of FADL methodology

- Identification of the shock of interest is done here at micro-level and hence separated from the estimation of common shocks.
- y_t does not need to be in X_t. Just test ex post whether it indeed has a factor structure.
- Restrictions on the responses of variables in X_t or Y_t, if any, are imposed equation by equation.
- In principle, any linear regression restriction can be imposed to shape the impulse response functions of interest. For example, to impose that y_t does not react on impact to $\hat{\varepsilon}_t$, it is sufficient to restrict $\alpha_\varepsilon(0) = 0$.

Overview of results

- Factor structure of data broadly validated
- Recessionary impact of a positive capital ratio shock
- Outstanding credit contracts while (C&I) loan interest rates rise: flavour of a supply shock
- Assymetric effects of shocks reducing vs augmenting bank leverage
- Robustness checks:
  - lag selection in FADL (baseline: [1,1,4])
  - exclusion of subprime crisis period

Testing the factor structure of selected macroeconomic series

	F-test p-value		R-squared	
REAL ECONOMY MEASURES	$\alpha(L)$	$\alpha_\varepsilon(L)$	Total	Marginal
Capacity utilization	0.0000	0.0568	0.7991	0.0267
GDP	0.0000	0.0917	0.7024	0.0185
Investment	0.0000	0.0088	0.5992	0.0422
Industrial production	0.0000	0.0329	0.7835	0.0406
Consumption	0.0000	0.6062	0.6368	0.0117
CPI	0.0000	0.0156	0.7660	0.0308
Housing starts	0.0000	0.0361	0.9651	0.0043
House prices	0.0000	0.3250	0.6487	0.0536
FFR	0.0000	0.8441	0.9643	0.0006
B-spread	0.0000	0.0008	0.9276	0.0151

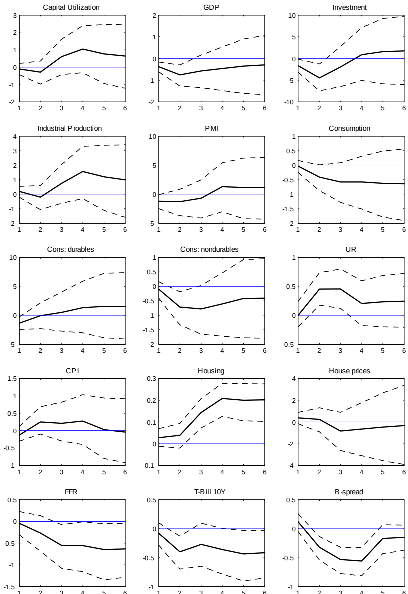
Table: Note: The F-test test the null that the coefficients in the FADL regression of a given macro series are jointly zero (col. 1). In the second column, we test the null that only coefficients of the bank leverage shocks are

Testing the factor structure of individual macroeconomic series.

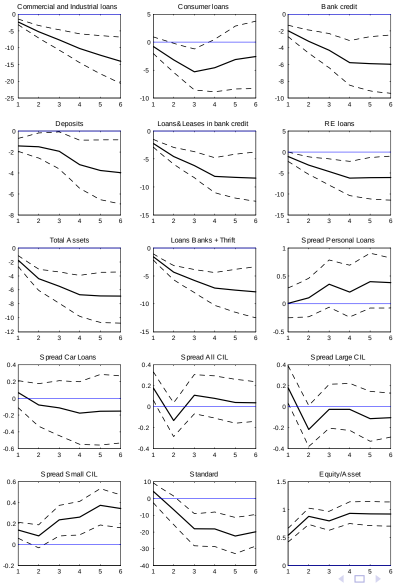
	F-test p-value		R-squared	
CREDIT MEASURES	$\alpha(L)$	$\alpha_{\varepsilon}(L)$	Total	Marginal
Commercial and industrial loans	0.0000	0.0595	0.8002	0.0267
Consumer loans	0.0014	0.0407	0.2616	0.0966
Bank credit	0.0000	0.0002	0.3646	0.1288
Deposits	0.0216	0.1429	0.2625	0.1039
RE loans	0.2277	0.1274	0.2425	0.0643
Spread All CIL	0.0000	0.0014	0.8307	0.0328
Spread Large CIL	0.0000	0.0009	0.8196	0.0333
Spread Small CIL	0.0000	0.0684	0.8821	0.0120
Standard	0.0000	0.0382	0.8668	0.0136
Equity / Assets	0.0000	0.0000	0.5131	0.3183

Table: Note: The F-test test the null that the coefficients in the FADL regression of a given macro series are jointly zero (col. 1). In the second column, we test the null that only coefficients of the bank leverage shocks are

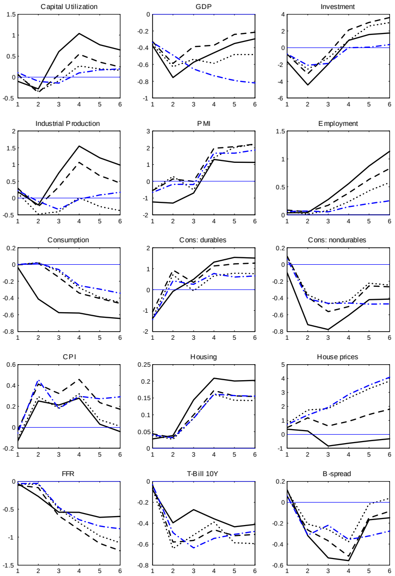
IRFs of macro series ($\in X_t$) to a shock reducing bank leverage



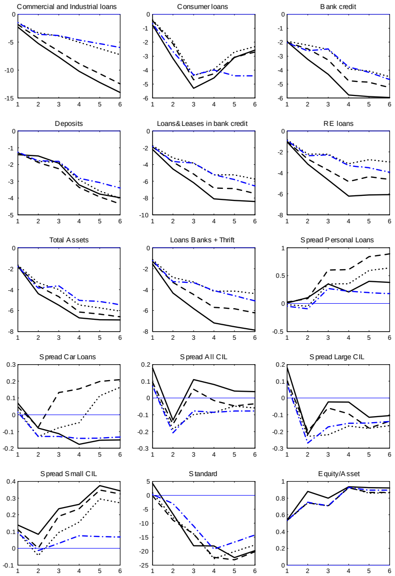
IRFs of credit series (not in X_t) to a shock reducing bank leverage



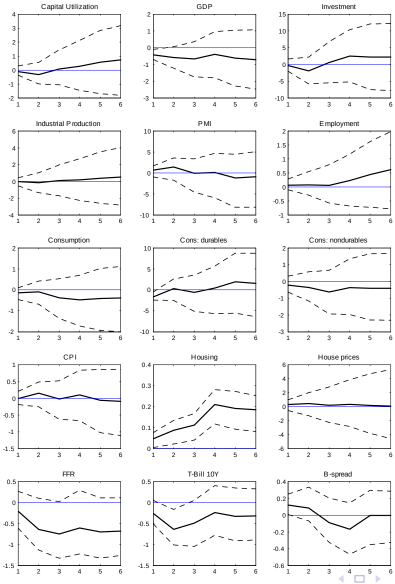
IRFs of macro variables to a shock reducing bank leverage: various specification of FADL



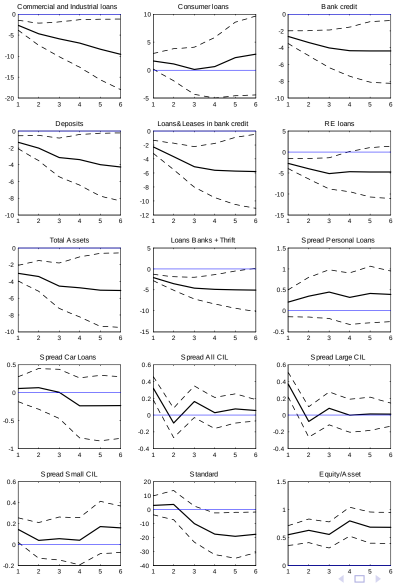
IRFs of credit variables to a shock reducing bank leverage: various specification of FADL



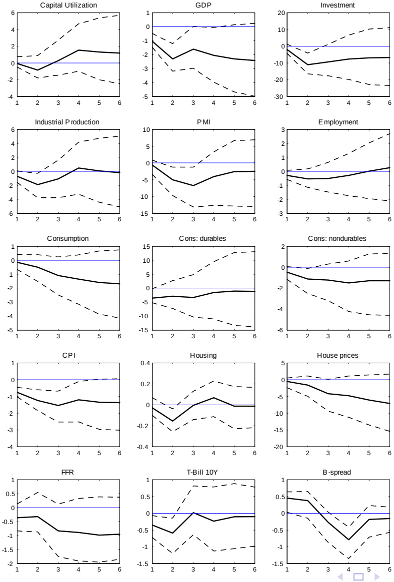
IRFs of macro series to a shock reducing bank leverage: with data up to 2008 Q2



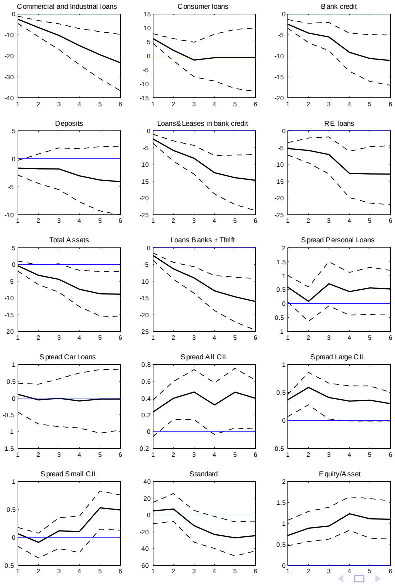
IRFs of credit series to a shock reducing bank leverage: with data up to 2008 Q2



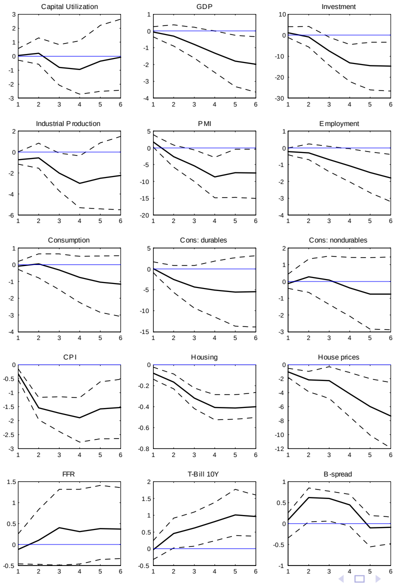
IRFs of macro series to an asymmetric shock reducing bank leverage



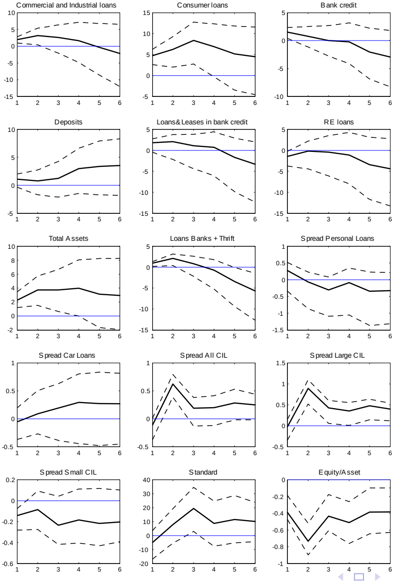
IRFs of credit series to an asymmetric shock reducing bank leverage



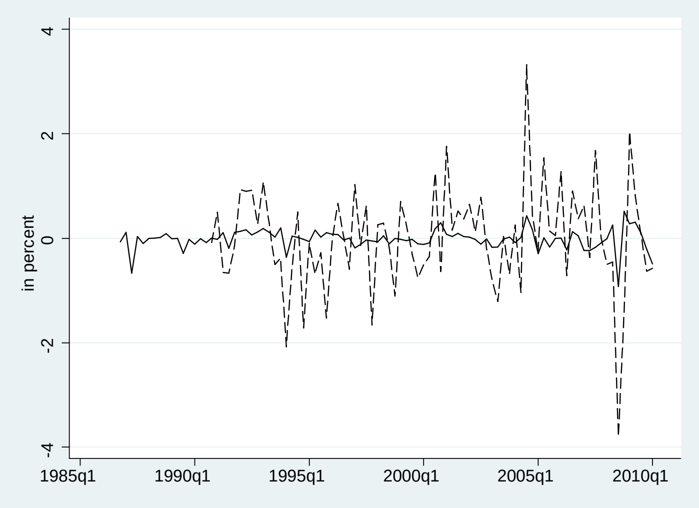
IRFs of macro series to an asymmetric shock augmenting bank leverage



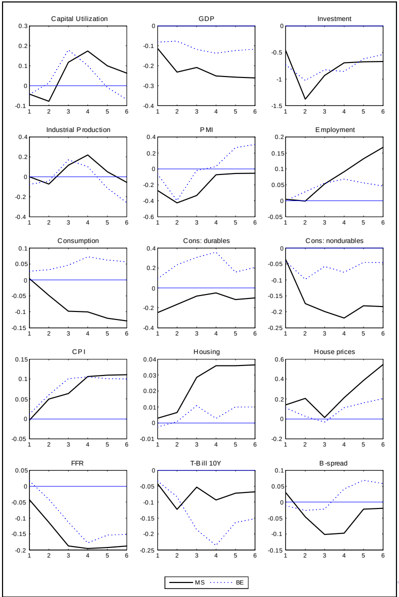
IRFs of credit series to an asymmetric shock augmenting bank leverage



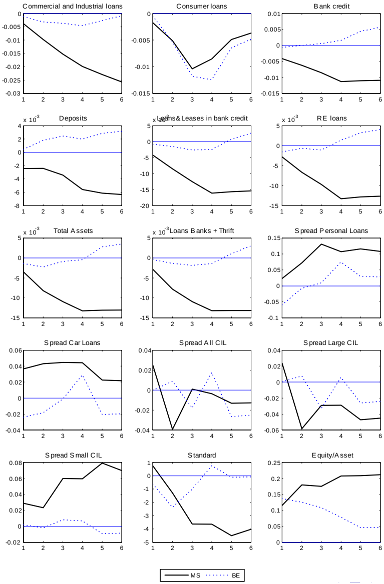
MS C/A shock vs shocks from a small-scale macro VAR (BE, 2010)



Comparison to shocks on aggregate bank capital ratio (BE) and credit standards (BCDZ)



Comparison to shocks on aggregate bank capital ratio (BE) and credit standards (BCDZ)



Conclusion

- We propose a new integrated two-step framework to identify economy-wide bank leverage shocks and their consequences, relying on a rich database that encompasses both bank balance sheet information (micro-level) and macroeconomic aggregates .
- We find that leverage shocks matter for understanding fluctuations in credit aggregates as well as the US business cycle.
- Policy implications:
  - Does not support necessarily claim that bank capital requirements should not be raised (Basel III): motives of the CAR shock unknown here
  - But gradual adjustment through retained earnings should be preferred.